Aerospace Fasteners Part II

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Background

In a past Fastener World Magazine Article, Aerospace vs. Automotive Threaded Fasteners – Jan/Feb 2008, I compared differences on threaded fasteners between the two industries. I discussed the physical differences which included strength, thread length, and specifications. I also discussed their relative costs as well as the coatings and platings on each of the industries offerings. In this article, I will continue the discussion, but concentrating on the use of cadmium plating in each of the two industries.

Back in the mid to late 1980's, both the aerospace as well as the automotive industries, world-wide used fasteners (threaded and non-threaded) that were plated in cadmium. Cadmium was, and still is, a fantastic plating. It is a thin sacrificial plating and it has a very consistent coefficient of friction (CoF). It has excellent resistance to corrosion, 96 hrs (minimum) of salt spray testing in-accordance-with (IAW) ASTM B117. It will not flake off on the threaded or under-head region when it is assembled in a joint and torque is applied via a socket, or equivalent. Most importantly, it was cheap to apply and it seemed that there was a cadmium plating shop on every corner (over exaggeration, I know). The only down side is that it sometimes requires a secondary top coat such as a chromate or phosphate treatment. Most aerospace fasteners specifications I have seen call out the chromate treatment. But alias, the party had to come to an end. For those of us old enough to have lived through the "Change", the use of cadmium in the automotive industry was on its way out.

The European Union passed regulations on toxic materials, which of course cadmium is considered one. The European automotive manufacturers did their part and soon led the way and started building their vehicles with cadmium free fasteners. Back in the United States, the initial reaction was of course non-existent (we companies do not have to listen or abide by the rules handed down by the EU). Well later we all know what happened, in order to sell vehicles or parts of vehicles in the European markets, all fasteners used in the manufacturing of said products had to be cadmium free.

I worked in a Fastener Test Lab for an automotive supplier back in the day of the Change. Early on, the trial lots of threaded fasteners coated with either Chrome 6 or Chrome 3 schemes were absolutely dismal. I would open the box of fasteners and most of the coating on the fasteners flaked off during shipment. We would all stand around and ask Really? Time marched on and the coatings got better. Now we faced a new issue of CoF. We would run tests in a torque/tension load-cell to measure the CoF values for both the thread and under-head regions. What we found was that the frictional values were hovering around the .2 level. If this trend continued, we would have to re-tool our plants with higher rated pneumatic and electric torque guns because the resulting final torque values would all have to increase. Now enter the dual or multi-layer coatings. Top coats suddenly were being used to bring the CoF values back down to the level of our beloved cadmium. The world of fasteners was now coming back to equilibrium. But this process took several years and we still had issues. The top coat was missing or not to the range per print. As the steps in a manufacturing process increase, the higher the probability of something going wrong.

Going Forward

The proceeding information was meant as a background for the rest of the article. The rest of the article talks about cadmium on threaded fasteners used in aerospace applications. We are now present day, and the year is 2013. The European community is at it again. This time it is called Clean Sky. At this point in time, we are not sure the extent at which this initiative will impact manufacturing process. The bottom line here is whether it means the end for cadmium on aircraft and aircraft related equipment or not.

On average, I have been told that there are about 1,100 fasteners on an average automobile. On the other hand, there might be over 1 million fasteners (threaded and non-threaded) on an aircraft. For the auto industry, if the drawing for a threaded fastener needed to be changed, one would change it. No other documentation would need to be changed. Life is not that easy with aerospace side. The bad word here is drawings or prints. For example, I am a government and want to make a plane with six wings. In order to issue a contract for the six winged aircraft, I need to have a set of drawings so my contractor can build exactly what I want. So I have a Level III drawing of the entire assembly (drawings of such detail that given a set, anyone with equipment and knowledge could create the final product). These drawings contain all the torque ranges for all the threaded fasteners used to assemble the sub-assemblies into the final assembly, the aircraft. If I changed my coating or plating on my threaded fasteners, these drawings would all have to be changed. Taking this further, I would have Level III drawings of the sub-assemblies that could contain torque information that would also have to be changed. In all these drawings, the type and quantities of fasteners used in the assembly are called out. Most all are controlled by industry standards or perhaps modified industry standard fasteners.

Now in a perfect world, the industry standard specifications would all change on their own (hundreds of specifications). There would then be no need then to change any of my government drawings for my 6 winged aircraft. But we do not live in this perfect world and the governments that own drawings are complex as well. For example, take a specification and call it ABC-X. It will have a shear rating and ultimate strength. All branches of the military use this threaded fastener. However, each branch has its own requirements. If the cadmium plating went away and was replaced by a new coating, the folks flying planes from aircraft carriers would need the coating to resist both salt water and perhaps sulphur (from jet engine exhausts). The folks flying planes from land would not need this requirement. So the two organizations would go their own respective ways and economies of scale for research and purchasing would cease to exist. So if you ran a specification organization, would you add countless options to your specs? The answer is no.

So if different aerospace organizations exist in a governmental group and they all had different requirements, they each would then have to update their own drawings. There could be hundreds of thousands of drawings to update. The man-hours required to perform such a task would be astronomical.

I have just talked about what would happen if coatings and platings already existed to meet all the demands and requirements of all aerospace groups. The idea of finding a replacement for cadmium for the aerospace community would be a relatively simple task. The automotive folks had already done the research and have products in the field operating for decades. But most governments do not operate this way. Committees would have to be formed. Studies on everything from environmental and financial impact of putting the cadmium plating shops out of business to the plight of the spotted salamander living nearby (you know this is true). People would point to the research performed by the automotive community and how some of the coatings/platings meet the newly established requirements. This would not matter because it is not research funded and controlled by the government. The replacement of cadmium in the automotive industry took what, 10 years to go from concept to reality? How long would it take any government to replace the cadmium on the fasteners used in their respective aerospace products? My guess is 20 years. Then there is the question of all those drawings.

Corrosion is a very big and real issue for fasteners in the aerospace community. There are two basic specifications for us here in the United States. ASTM B117 (Standard Practice for Operating Salt Spray (Fog) Apparatus) and ASTM G85 Annex 4 (Standard Practice for Modified Salt Spray (Fog) with the addition of SO2 Salt Spray, Cyclic Testing. Most everyone is aware of the 117 spec, but not so with the G85. There are some automotive coatings existing today that will pass say 300 hrs of the G85 specification, but not many. Of these, some come with multiple coatings to meet both the corrosion requirements as well as the CoF requirements (matching those of the cadmium plating).

One small additional environmental concern for a new coating or plating is temperature. Throwing out a few numbers are -70°C to +70°C. Well let's add some vibration and a few 8-10g loadings just to make things interesting. Cadmium could handle all this with minimal issue. Could a replacement do the same?

Conclusion

Replacing the cadmium on automotive fasteners was not an easy and straight forward task. Lots of parts were consumed in the test and evaluation of all the different iterations thrown at the industry. But in the end, it was worth it. Doing the same thing with the aerospace industry is a different task. There are actually two fronts, civilian aerospace and government aerospace. Of course, why should the civilian side of the industry change when the government side does not. The author believes that ultimately, the aero industry will change, but it will not be quick and it will not be easy. Drawings, government bureaucracy, and the meetings (which usually involve presentations that we here in the US call "death by Powerpoint" - the material and slides just go on and on until you want to drop you face into your cup of coffee and drown yourself).